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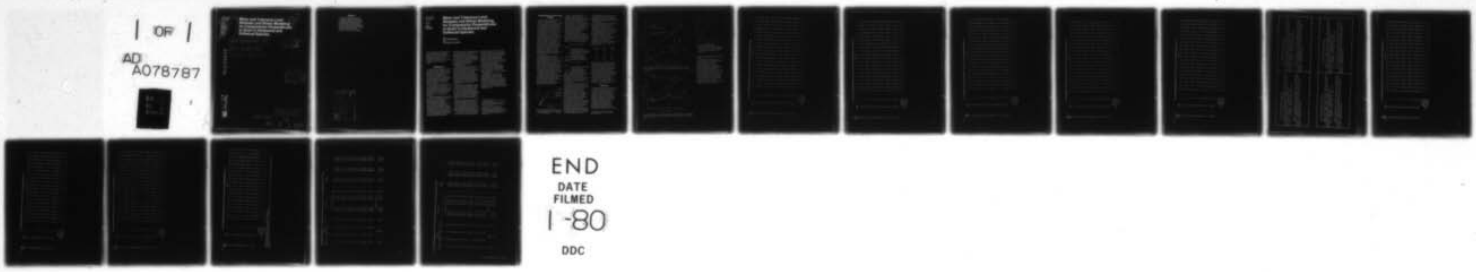

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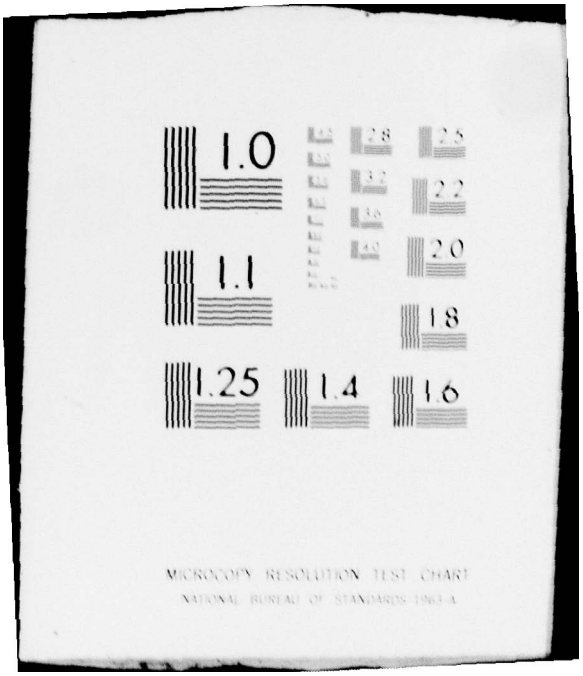
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United States Department of Agriculture

Forest Service

Forest Products Laboratory

Research Paper FPL 337

1979

Mean and Tolerance Limit Stresses and Stress Modeling for Compression Perpendicular to Grain in Hardwood and Softwood Species.

FSRP-FPL-337

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Abstract

Tables characterizing the stress-compression relationship of wood in compression perpendicular to grain for several species are presented here. Complete characterization results are included, as well as selected regression models for characterizing other species. Use of the tables and models is illustrated via discussion and graphs.

United States
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**Forest
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Mean and Tolerance Limit Stresses and Stress Modeling for Compression Perpendicular to Grain in Hardwood and Softwood Species

By
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and
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Earlier research into procedures for characterizing stress-compression behavior in wood for compression perpendicular to grain (C-perp), and for modeling this behavior, was published.[2,3] This paper presents more detailed results of the previous research.

Background

Allowable design stresses for wood in C-perp are currently based upon the average proportional limit (PL) stress determined from tests of small, clear specimens. This design base is excessively conservative. A need for a more appropriate C-perp design base has become apparent because of today's more efficient engineering design with wood.

Thus, a procedure was developed for characterizing the C-perp stress-compression relationship of wood.[3] This characterization procedure utilizes the original test records of specimen test results that form the current C-perp design base[4]—no new testing is required.

The procedures previously reported[3] were used to characterize the C-perp behavior of nine softwood and hardwood species or species subgroups: Coast Douglas-fir, interior north Douglas-fir, shortleaf pine, western hemlock, Engelmann spruce, white spruce, Pacific silver fir, aspen, and northern red oak. This research is reported in footnote 2. The output for each species characterization consists of: (1) nonparametric tolerance limit stresses for each of 20 levels of compression and for all combinations of six tolerance regions, ranging from 50 to 90 percent content, and five confidence levels from 75 to 99 percent; (2) the mean ($\bar{x}$), standard deviation (s), and coefficient of variation for stresses at each level of compression; and (3) dry/green ratios for average interpolated stresses at each compression level.

Characterization results from the nine species or species subgroups were used by the authors[2] in the development of a number of different models for predicting the stress-compression behavior in wood at both the mean and near minimum stress levels. Several different predictors were employed as independent variables and logarithmic transformations of both the dependent and independent variables were explored.

The simple linear regression model containing the average D 2555[4] C-perp PL as the predictor variable provided the "best fit" of the models explored. The appropriateness of this model to the current visual stress grading system in the United States was illustrated by application to white fir. The model is applicable to all species tabulated in D 2555.

Only highly abridged characterization results for one species and the one model containing the average C-perp PL were published earlier.[2] However, models containing modulus of elasticity (E) and specific gravity (SG) as the predictor variable may also be germane to improving the grading technology.

For example, in current practices for both visual and machine stress rated (MSR) lumber, no distinction is made between grades for C-perp allowable stresses: the same stress is assigned to all grades. Models containing E as a predictor may provide a basis for assigning C-perp stresses in MSR grading systems in accord with current practice for other properties. Similarly, SG may be an appropriate nondestructive test parameter for grade-dependent C-perp allowable values in the current visual grading system. SG at least could provide a basis for assigning a "bonus" to grades of high density.

This possible interest in further developments of visual and MSR grading systems, and the lack of published information on C-perp stress-compression behavior—particularly at near-minimum stress levels—suggest the value of complete characterization results (table 1) and selected regression results for models containing E and SG (tables 2 and 3).

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Bendtsen, B. A., and W. L. Galligan. 1979. Modeling the stress-compression relationships in wood in compression perpendicular to grain. For. Prod. J. 29(2):42-48.

[3] Bendtsen, B. A., J. H. Haskell, and W. L. Galligan. 1977. Characterizing the stress-compression relationship of wood in compression perpendicular to grain. Wood Sci. 10(3):111-121.

[4] American Society for Testing and Materials. 1978. Standard methods for establishing clear wood strength values. ASTM desig. D 2555-76. Philadephia, Pa.

Interpretation and Use of the Tables

Characterization results for the nine species or species subgroups previously evaluated[2] are given in table 1. Individual stress values in the table represent either a species average stress or a tolerance limit stress for a given species and compression level. For example, the mean stress for a Coast Douglas-fir at the 0.05-inch level of compression is 738 pounds per square inch (lb/in.^{2}) (p. 1, 4th line from bottom under the heading "0.050"). If the 25 percent tolerance limit (75 pct tolerance region content) with 75 percent confidence is desired for the 0.05-inch level of compression, the appropriate line is selected using the first two columns on the left. Reading across to the "0.050" column, the tolerance limit is 568 lb/in.^{2} (which reflects the strength of the 156th weakest of the sample of 654 specimens for Coast Douglas-fir—see column heading "m").

The characterization process[3] demonstrated that the stress required to achieve a deformation is a highly skewed distribution. That is one reason why the nonparametric approach was used for determining the tolerance limits in table 1. The standard deviations and coefficients of variation reported in table 1 should be used with caution because of the demonstrated skewness.

Stresses from any single line in table 1, when plotted as a function of compression level, illustrate stress-compression relationships for a species at a mean or a tolerance limit level. Figure 1 shows such plots for shortleaf pine. The top line of the figure represents mean behavior; the two lower lines are tolerance limits.

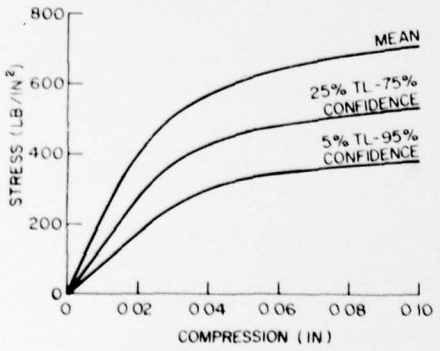

Figure 1.—Stress-compression behavior for the mean and two tolerance limits (TL) of shortleaf pine. (M 146 878)

Figure 1 is not presented as an analysis of results. Rather, it demonstrates the interpretation and use of table 1 data. Interpretation of the mean behavior line in figure 1 is obvious; the tolerance limit lines are somewhat less so. The bottom line, for example, should be interpreted as follows: We are 95 percent confident that 95 percent of shortleaf pine material will exceed stresses interpolated from the line.

Regression statistics for models containing modulus of elasticity, E as the predictor variable are presented in table 2. Similar statistics for specific gravity, SG, as the predictor appear in table 3. The model containing E is:

$$\log_{10} \hat{y} = A + B \log_{10} x$$

where

$\hat{y}$ = an estimated mean or tolerance limit stress for any compression level of interest,

x = a species average E value from D 2555, and

A and B = appropriate regression statistics from table 2.

The model using SG as the predictor variable is:

$$\hat{y} = A + Bx$$

where

x = a species average SG value from D 2555 and

A and B = appropriate regression statistics from table 3.

These models were selected as best fitting, based upon R^2 analysis, from those containing E and SG as estimators. Details of the development and application of the models are similar to those for the model involving the C-perp PL.[2]

The models containing E and SG are illustrated in figures 2 and 3 for the mean and the 25 percent tolerance limit (75 pct confidence) at 0.06-inch compression. Values of y for the regressions in figures 2 and 3 are obtained from table 1—one value for each of the nine species evaluated. Values of x are either an average E value (fig. 2) or an average SG value (fig. 3) from ASTM D 2555[4] for corresponding species. In each figure, the upper line is a model for estimating mean behavior; the lower line, near minimum or a tolerance limit behavior. Note that a tolerance limit has confidence associated with it. However, the estimated tolerance limits obtained from these models do not. Confidence in these estimates, if desired, is obtained by standard procedures for calculating lower limits on regression estimates of values of y.[2,5] Statistics for making this computation are included in tables 2 and 3.

A composite diagram of the mean or a near minimum stress-compression behavior from zero to 0.1-inch compression can be developed for any species using table 2 or table 3 data. For example, mean behavior is obtained by use of regressions 31 through 35 from either table; the 25 percent tolerance limit with 75 percent confidence is obtained with regressions 11 through 15. If a species has an average E of 1.6 million lb/in.^{2}, estimated mean stresses and those for the tolerance limit and confidence mentioned are:

Compression level	Mean stress	Tolerance limit stress
In.	*Lb/in.^{2}*	*Lb/in.^{2}*
0.02	*551*	*393*
.04	*738*	*561*
.06	*813*	*631*
.08	*871*	*668*
1.0	*923*	*713*

and the stress-compression diagrams appear as in figure 4. Stresses in the tabulation here are not design stresses. Further modifications for ring angle, seasoning, and design considerations may be required. One method for making those modifications is detailed in an example presented elsewhere.[2] In that example, the average C-perp PL is used as the estimator variable. However, details of the procedures outlined in the example are also applicable to stresses developed using either E or SG as the predictor.

Summary

Detailed results of earlier research on the stress-compression relationships in C-perp for several softwood and hardwood species are given in table 1. The mean C-perp stress, standard deviation, coefficient of variation, and several nonparametric tolerance limit stresses are tabulated. Ratios of the average dry to the average green stresses are also given for each compression level. Graphical interpretation of selected data for shortleaf pine is given in figure 1 to illustrate the development of composite

[5]Freese, Frank. 1974. Elementary statistical methods for foresters. U.S. Dep. Agric., Handb. 317. Washington, D.C.

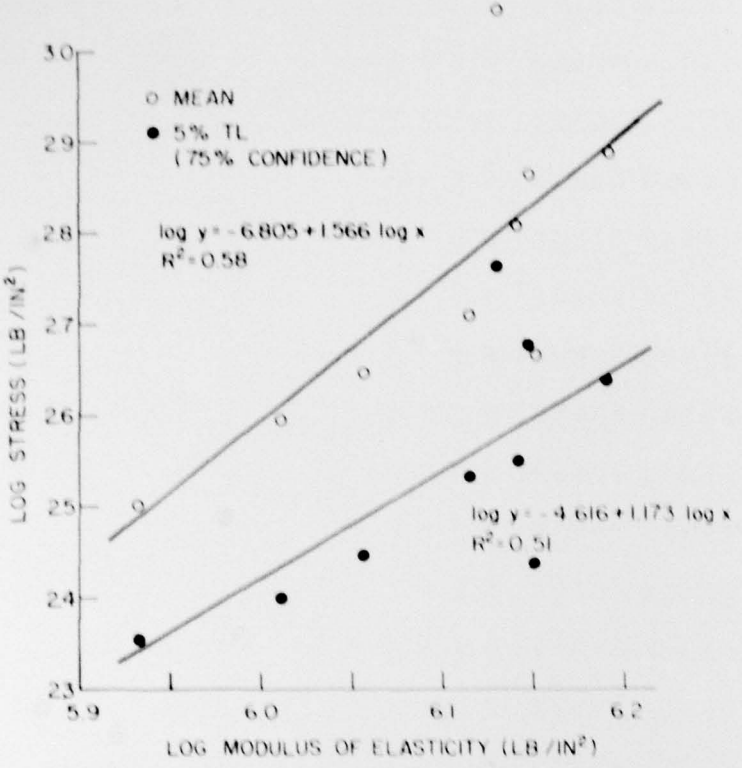

Figure 2.—Regression models with modulus of elasticity as a predictor for estimating mean and tolerance limit (TL) stresses at the 0.06-inch level of compression.

(M 146 880)

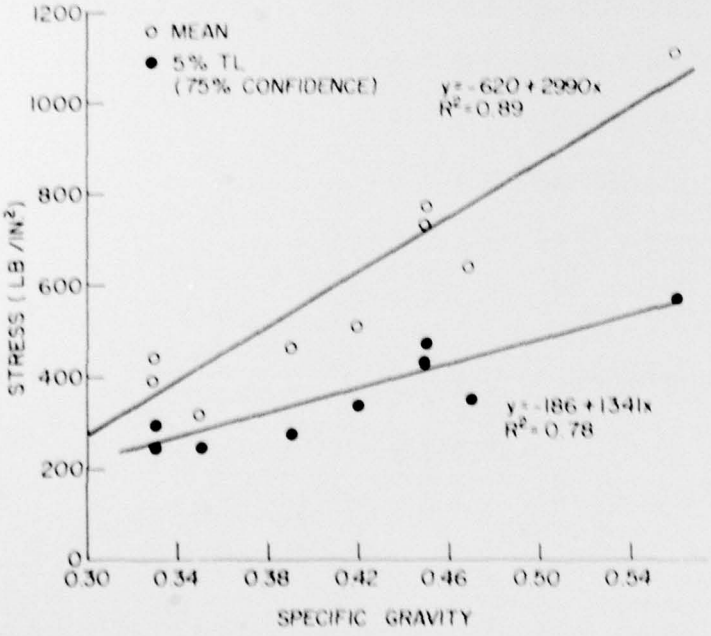

Figure 3.—Regression models, with specific gravity as a predictor, for estimating mean and tolerance limit (TL) stresses at the 0.06-inch level of compression.

(M 146 881)

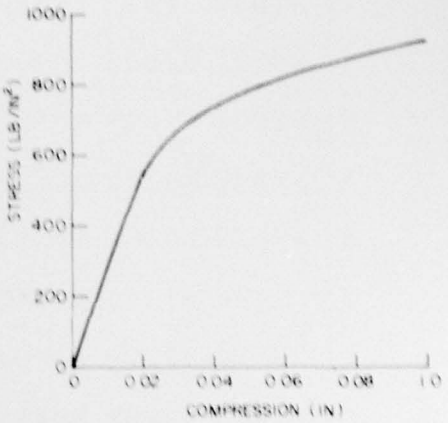

Figure 4.—Estimated stress-compression behavior at the mean and a tolerance limit level in a species assumed to have an average modulus of elasticity of 1.6 x 10^6 lb/in.^{2}.

(M 146 879)

stress-compression diagrams from table 1 data.

The data in table 1 were used in earlier research for developing models for predicting C-perp stress-compression behavior in D 2555 species. Parameters for regression models using species average E or SG values as predictor variables are presented in tables 2 and 3. The models are illustrated for the mean and a selected tolerance limit at the 0.06-inch level of compression in figures 2 and 3, and for the development of the stress-compression behavior for a species in figure 4. Figures 2, 3, and 4 are presented to demonstrate the use of the regression models in tables 2 and 3.

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Coast Douglas-fir)

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (in.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
99	99	1	26	57	86	116	145	172	198	218	233	242	246	248	248	248	247	248	250	253	257	262
99	95	3	28	59	95	134	167	202	234	265	297	324	343	364	375	383	388	398	408	415	420	424
99	90	3	28	59	95	134	167	202	234	265	297	324	343	364	375	383	388	398	408	415	420	424
99	80	4	30	65	104	145	185	230	261	284	304	327	349	367	377	390	397	403	409	415	421	428
99	75	5	35	71	106	149	185	231	267	294	315	336	355	367	379	392	403	409	413	417	422	428
95	99	20	50	98	144	196	243	283	312	350	372	388	405	422	433	442	451	459	464	471	476	483
95	95	24	52	107	156	210	259	296	327	353	376	399	414	427	441	449	456	464	471	476	485	491
95	90	26	53	108	160	214	263	305	331	358	381	404	421	433	443	452	461	467	474	481	486	494
95	80	28	54	110	161	214	266	311	336	365	383	408	423	435	446	455	464	470	477	483	490	497
95	75	29	55	110	161	216	266	311	340	365	387	408	424	435	447	457	465	472	477	487	495	502
90	99	48	67	128	187	251	299	346	380	416	439	452	465	477	487	494	503	510	517	527	532	535
90	95	53	68	133	195	258	305	359	394	424	445	459	471	481	492	499	507	516	523	530	538	543
90	90	56	70	136	202	260	312	365	403	426	447	463	476	486	493	501	509	520	525	534	540	546
90	80	59	71	141	207	267	318	370	407	431	450	465	479	487	495	506	514	522	530	537	542	546
90	75	60	72	143	210	269	321	371	409	432	450	466	480	491	499	507	514	522	530	537	544	547
80	99	107	91	183	270	331	386	426	455	485	507	521	535	549	561	568	575	583	591	599	609	617
80	95	114	93	188	276	340	396	437	465	491	513	531	544	557	567	578	587	593	603	610	618	624
80	90	118	94	193	277	345	401	446	470	496	516	534	548	563	573	581	588	596	607	614	623	632
80	80	122	97	196	280	355	407	451	477	502	526	539	556	567	576	584	593	600	612	621	627	635
80	75	124	98	197	286	360	408	453	482	506	523	540	558	568	578	586	596	603	612	622	631	636
75	99	138	102	205	298	373	425	468	497	522	540	555	569	579	589	601	610	619	628	634	644	652
75	95	145	103	212	304	380	432	478	507	528	544	560	575	584	595	604	612	623	632	640	648	657
75	90	149	106	213	306	382	434	482	511	530	548	563	576	588	598	607	615	625	635	643	653	660
75	80	154	108	216	310	386	439	488	515	531	552	567	580	594	606	615	623	632	641	650	657	666
75	75	156	108	217	311	387	445	491	517	536	553	568	581	596	607	616	626	635	644	651	659	667
50	99	297	154	303	428	519	584	625	649	674	691	708	726	741	755	766	780	793	801	812	822	830
50	95	306	157	308	438	527	590	634	656	681	697	716	731	747	759	773	786	797	809	820	831	842
50	90	311	158	313	439	530	593	638	662	685	703	718	734	751	763	778	788	802	814	824	833	844
50	80	316	158	317	441	533	596	647	669	692	707	722	739	753	768	781	793	806	816	826	838	849
50	75	318	160	317	442	535	598	647	670	694	709	722	740	755	769	784	795	807	816	827	840	850
	MEAN ($n = 954$)		177	339	459	546	604	647	676	700	720	738	754	770	784	798	810	822	833	844	854	864
	STANDARD DEVIATION		101	164	192	205	208	208	207	207	208	210	213	215	218	222	225	228	231	233	235	237
	COEFFICIENT OF VARIATION		57	48	42	38	34	32	31	30	29	28	28	28	28	28	28	28	28	28	28	27
	DRY/GREEN RATIO		1.79	1.79	1.83	1.88	1.92	1.93	1.93	1.92	1.91	1.90	1.87	1.85	1.83	1.81	1.80	1.78	1.77	1.76	1.75	1.74

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (interior north Douglas-fir)–continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (in.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
.99	.90	1	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470
.99	.80	1	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470
.99	.75	1	47	100	145	179	245	309	337	360	377	392	403	411	419	426	434	442	450	457	464	470
.95	.99	5	60	113	169	231	285	331	366	397	412	427	437	446	456	467	476	483	490	498	507	515
.95	.95	7	66	132	191	256	297	342	382	409	420	438	447	455	462	469	477	488	498	503	510	517
.95	.90	8	69	134	192	263	315	358	386	413	427	445	454	463	470	479	485	492	499	510	519	529
.95	.80	9	70	134	199	264	321	371	396	414	433	447	462	470	477	482	488	497	502	510	521	530
.95	.75	10	70	134	203	271	322	372	397	414	441	452	466	475	478	484	491	497	506	513	522	535
.90	.99	14	74	142	212	276	337	379	415	442	460	471	480	487	495	506	515	523	528	532	549	551
.90	.95	16	78	146	216	282	341	387	421	443	466	483	495	504	511	521	531	539	545	551	556	565
.90	.90	18	80	146	222	293	346	395	423	457	469	486	499	508	522	535	538	543	549	552	561	574
.90	.80	20	80	157	224	304	355	400	434	462	479	497	506	517	528	538	546	550	556	566	572	578
.90	.75	21	81	159	233	307	359	400	436	463	484	498	509	518	529	538	546	554	561	568	573	580
.80	.99	34	87	172	257	327	389	441	468	501	516	530	538	551	561	569	578	588	594	597	603	607
.80	.95	37	91	174	265	334	393	450	483	508	520	533	547	559	566	576	581	592	601	610	621	632
.80	.90	40	93	176	268	342	398	454	487	513	531	544	555	564	574	584	595	606	616	625	630	634
.80	.80	42	95	183	273	350	401	461	494	515	534	551	562	572	580	588	598	608	619	628	634	638
.80	.75	43	95	184	276	354	403	465	501	516	538	553	564	574	584	596	605	612	622	629	637	640
.75	.99	44	95	184	276	355	408	465	502	523	539	554	565	577	586	597	607	617	625	629	637	644
.75	.95	48	99	192	284	360	417	474	511	530	547	563	576	584	595	606	615	623	633	638	648	659
.75	.90	51	100	197	285	364	422	477	517	539	553	569	581	591	600	611	621	632	641	645	655	663
.75	.80	54	103	202	286	370	428	478	520	547	561	574	588	596	608	619	628	637	645	658	668	674
.75	.75	55	104	203	287	371	433	481	521	548	562	575	589	600	610	620	628	637	648	658	668	678
.50	.99	101	130	260	365	455	522	575	607	624	639	652	664	675	688	700	710	721	734	741	750	760
.50	.95	106	132	264	370	459	524	584	618	630	644	662	674	686	696	708	715	725	735	745	755	766
.50	.90	109	133	265	374	465	526	589	622	639	656	668	678	688	699	709	719	730	739	748	758	767
.50	.80	112	135	270	378	468	530	593	623	642	659	675	687	698	706	714	724	732	744	755	765	781
.50	.75	113	137	270	379	468	535	594	625	642	659	675	689	698	707	715	724	735	748	757	773	783
	MEAN (n=237)		149	293	408	496	562	612	645	669	687	703	717	729	741	753	764	775	786	796	805	815
	STANDARD DEVIATION		55	107	136	151	158	161	163	165	166	168	169	171	174	176	179	181	184	186	187	189
	COEFFICIENT OF VARIATION		37	37	33	30	28	26	25	25	24	24	24	23	23	23	23	23	23	23	23	23
	DRY/GREEN RATIO[3]																					

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Shortleaf pine)–continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (in.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
99	90	1	36	71	104	139	171	202	225	234	242	250	257	265	271	278	284	290	296	301	306	312
99	80	1	36	71	104	139	171	202	225	234	242	250	257	265	271	278	284	290	296	301	306	312
99	75	2	37	75	114	157	194	214	231	267	282	284	286	290	294	300	306	313	320	327	334	341
95	99	6	44	88	130	170	208	252	279	295	314	324	336	341	343	346	350	353	352	351	353	361
95	95	8	46	91	133	178	222	255	280	308	320	333	340	348	352	354	354	360	370	380	384	385
95	90	9	46	92	135	181	223	259	286	313	324	334	341	349	354	361	366	371	377	382	386	388
95	80	11	47	95	144	191	235	267	299	315	328	337	346	355	362	369	375	378	381	383	390	398
95	75	11	47	95	144	191	235	267	299	315	328	337	346	355	362	369	375	378	381	383	390	398
90	99	16	53	104	151	200	249	289	309	329	344	357	365	373	380	388	392	398	402	407	410	414
90	95	19	55	109	155	207	253	294	321	342	351	364	376	385	390	395	398	403	407	411	414	419
90	90	21	55	110	160	212	256	297	324	342	355	367	377	387	393	399	405	410	415	420	425	428
90	80	23	56	111	162	215	262	298	335	345	360	373	381	387	395	403	409	413	418	425	432	440
90	75	24	56	112	164	215	264	303	336	346	361	374	381	395	399	405	413	421	429	437	443	448
80	99	40	64	130	187	248	304	342	371	392	408	421	436	442	446	451	455	458	468	476	482	489
80	95	44	68	133	192	253	307	349	383	401	414	431	441	452	457	463	468	473	478	485	492	499
80	90	46	68	134	194	256	308	356	385	401	419	436	444	452	460	467	476	484	485	487	496	507
80	80	49	69	136	197	260	313	359	389	406	421	438	451	461	464	475	482	487	496	503	505	510
80	75	50	69	137	197	261	314	360	390	407	426	439	453	463	470	480	486	492	496	504	507	510
75	99	52	70	139	200	265	319	365	392	412	428	442	457	469	479	485	489	497	503	506	512	515
75	95	57	71	143	212	271	326	371	400	418	433	451	465	474	484	493	502	506	510	517	521	527
75	90	59	72	143	213	275	328	372	401	420	436	454	466	476	485	496	505	508	512	518	524	530
75	80	62	72	145	215	281	338	375	402	429	446	458	470	478	491	501	506	512	515	521	529	535
75	75	63	73	146	215	282	340	376	402	429	448	459	470	479	492	501	506	513	517	522	529	537
50	99	117	96	192	278	356	419	460	495	513	529	543	555	564	573	584	596	608	619	625	630	636
50	95	123	99	194	284	365	425	466	502	521	537	554	566	578	589	601	609	616	624	633	640	646
50	90	126	100	200	288	367	428	469	508	527	542	559	573	582	595	607	614	619	628	637	644	651
50	80	130	100	204	288	377	435	483	515	538	559	567	577	590	599	609	618	627	634	640	649	657
50	75	131	100	204	289	378	435	484	517	541	561	569	578	590	600	611	619	629	635	642	649	659
	MEAN (n=273)		115	229	319	401	463	513	546	573	593	611	626	640	651	663	673	681	690	697	706	713
	STANDARD DEVIATION		55	106	133	151	161	167	171	177	182	188	193	198	201	204	207	210	212	215	218	221
	COEFFICIENT OF VARIATION		48	46	42	38	35	33	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	DRY/GREEN RATIO		1.75	1.76	1.89	1.99	2.06	2.10	2.12	2.13	2.13	2.13	2.13	2.12	2.11	2.10	2.08	2.07	2.06	2.05	2.04	2.02

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Western hemlock)—continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (In.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
.99	.80	1	31	63	97	133	164	193	212	227	240	252	263	272	279	283	287	291	295	299	304	308
.99	.75	1	31	63	97	133	164	193	212	227	240	252	263	272	279	283	287	291	295	299	304	308
.95	.99	4	35	70	105	139	174	212	241	268	283	294	309	330	343	351	358	363	368	367	371	376
.95	.95	6	40	79	115	157	201	229	250	274	296	311	325	337	348	357	363	366	371	376	381	386
.95	.90	7	41	81	119	162	201	231	255	277	299	315	328	338	348	357	363	371	379	384	390	395
.95	.80	8	41	82	120	164	201	232	257	280	303	319	331	341	349	360	364	372	379	386	392	397
.95	.75	8	41	82	120	164	201	232	257	280	303	319	331	341	349	360	364	372	379	386	392	397
.90	.99	12	45	88	134	177	214	248	269	298	315	328	341	352	358	366	376	383	388	395	399	402
.90	.95	14	46	91	136	181	219	254	278	301	316	333	348	359	364	372	379	387	393	401	407	411
.90	.90	16	46	92	136	183	222	256	280	303	322	340	356	363	368	374	381	391	396	405	409	415
.90	.80	17	46	93	140	184	225	257	283	307	330	344	356	364	372	380	388	394	400	405	410	419
.90	.75	18	47	93	140	185	226	258	285	312	330	347	357	368	376	383	389	395	401	410	415	419
.80	.99	29	49	103	146	197	237	276	304	328	347	362	371	379	389	399	407	412	418	426	433	440
.80	.95	33	52	105	152	207	243	281	313	332	351	363	373	386	395	403	409	418	425	432	439	445
.80	.90	35	53	106	156	207	245	286	315	337	353	364	376	386	396	404	413	420	427	433	440	446
.80	.80	37	54	107	158	210	249	287	315	340	354	366	378	390	399	406	413	420	427	435	442	447
.80	.75	38	56	108	161	210	250	290	317	341	355	367	379	391	401	407	414	421	428	436	443	450
.75	.99	38	56	108	161	210	250	290	317	341	355	367	379	391	401	407	414	421	428	436	443	450
.75	.95	42	56	116	171	218	258	292	319	343	360	374	385	395	405	415	421	429	436	440	446	453
.75	.90	45	59	118	175	224	260	295	323	345	364	377	389	399	407	417	426	432	440	447	453	454
.75	.80	47	60	121	177	228	263	296	324	348	365	379	391	400	408	418	427	433	440	447	455	459
.75	.75	48	60	121	177	228	264	297	324	348	367	381	391	400	409	420	427	433	441	450	456	460
.50	.99	88	75	153	218	278	326	363	381	400	412	422	435	448	461	471	480	488	492	496	506	514
.50	.95	93	76	156	224	286	333	369	397	408	421	433	444	455	467	478	487	496	504	509	517	524
.50	.90	96	77	159	227	291	340	375	402	416	427	440	449	460	471	481	489	497	506	515	522	530
.50	.80	99	77	160	231	294	345	382	408	426	436	448	454	467	475	486	493	502	512	523	531	537
.50	.75	100	78	160	233	294	348	384	410	428	436	448	456	467	479	487	497	506	514	523	533	542
	MEAN (n = 210)		87	174	250	318	370	409	435	457	474	489	501	513	523	534	543	551	560	568	576	584
	STANDARD DEVIATION		38	75	98	114	121	126	128	130	132	133	135	137	139	141	143	145	147	149	151	153
	COEFFICIENT OF VARIATION		44	43	39	36	33	31	29	28	28	27	27	27	27	26	26	26	26	26	26	26
	DRY/GREEN RATIO		1.94	1.96	2.01	2.01	2.00	1.99	1.98	1.98	1.98	1.97	1.96	1.96	1.95	1.94	1.94	1.93	1.92	1.91	1.91	1.90

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Pacific silver fir)—continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (In.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
95	99	2	26	52	75	99	122	146	169	190	206	218	227	235	242	248	253	257	261	264	267	270
95	95	3	27	55	83	111	135	157	174	191	208	221	236	248	258	266	274	281	287	292	297	303
95	90	4	32	60	83	116	149	174	195	219	240	254	259	264	268	272	277	282	288	295	300	304
95	80	5	36	70	103	137	172	208	234	242	249	255	266	275	283	292	299	307	313	320	325	328
95	75	5	36	70	103	137	172	208	234	242	249	255	266	275	283	292	299	307	313	320	325	328
90	99	6	37	74	112	148	181	212	236	257	272	272	275	282	290	300	310	314	318	321	326	333
90	95	8	39	79	114	152	185	223	245	264	274	282	290	302	314	318	322	327	332	339	345	350
90	90	9	44	90	121	160	198	226	247	266	276	283	293	304	314	321	326	331	335	340	346	353
90	80	11	47	91	132	176	209	232	258	271	278	294	309	313	315	324	332	339	346	351	354	355
90	75	11	47	91	132	176	209	232	258	271	278	294	309	313	315	324	332	339	346	351	354	355
80	99	17	49	96	140	186	219	254	271	280	295	306	316	325	333	340	347	353	361	367	372	380
80	95	20	50	100	146	190	230	264	278	300	307	317	319	326	338	350	359	366	372	377	381	386
80	90	21	51	101	147	193	234	264	285	303	315	318	321	327	341	351	359	368	377	384	389	398
80	80	23	52	102	148	197	237	268	285	306	320	322	328	335	343	352	360	370	379	387	394	401
80	75	24	53	103	149	199	237	269	286	308	321	328	339	349	358	363	367	372	379	388	395	402
75	99	23	52	102	148	197	237	268	285	306	320	322	328	335	343	352	360	370	379	387	394	401
75	95	26	53	105	151	203	241	274	292	309	323	334	343	352	361	366	373	379	385	390	397	403
75	90	28	54	106	157	204	242	275	295	317	326	340	351	358	364	373	380	386	391	397	403	410
75	80	30	55	108	162	207	245	276	301	317	332	346	355	360	368	375	380	388	396	403	409	413
75	75	31	55	110	162	208	247	277	303	319	333	346	358	363	369	376	383	389	396	403	411	419
50	99	55	70	139	193	241	280	314	339	358	370	383	396	403	411	420	429	438	446	454	460	465
50	95	59	72	145	198	245	287	326	345	365	378	391	401	411	423	433	441	447	458	464	473	477
50	90	61	74	148	201	252	297	327	349	366	381	395	404	414	425	436	443	451	460	467	474	480
50	80	64	75	148	211	263	302	332	355	371	383	400	416	424	433	438	449	455	464	473	479	485
50	75	65	75	148	211	264	305	333	356	373	386	401	417	428	433	440	449	458	465	474	480	486
	MEAN (n = 137)		84	166	235	293	339	372	395	414	429	442	453	463	473	482	491	500	508	516	524	532
	STANDARD DEVIATION		35	69	94	110	119	124	126	128	131	133	135	136	138	140	142	144	146	148	149	151
	COEFFICIENT OF VARIATION		42	42	40	38	35	33	32	31	31	30	30	29	29	29	29	29	29	29	28	28
	DRY/GREEN RATIO		1.98	2.03	2.05	2.06	2.07	2.09	2.09	2.09	2.08	2.07	2.06	2.05	2.03	2.02	2.00	1.99	1.98	1.98	1.97	1.96

U.S. Forest Products Laboratory.

Mean and tolerance limit stresses and stress modeling for compression perpendicular to grain in hardwood and softwood species; by B. Alan Bendtsen, and William L. Galligan. Madison, Wis., FPL.
15 p. (USDA For. Serv. Res. Pap. FPL 337).

Tables characterize stress-compression relationship of wood in compression perpendicular to grain for several species. Other species can be characterized through selected regression models.

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Tables characterize stress-compression relationship of wood in compression perpendicular to grain for several species. Other species can be characterized through selected regression models.

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Engelmann spruce)—continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (In.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
.95	.90	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.95	.80	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.95	.75	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.90	.99	1	36	72	110	147	182	211	223	232	238	243	248	252	256	260	263	267	271	275	278	282
.90	.95	2	46	94	137	172	196	212	235	255	273	282	288	294	299	304	308	313	318	322	326	329
.90	.90	2	46	94	137	172	196	212	235	255	273	282	288	294	299	304	308	313	318	322	326	329
.90	.80	3	57	117	155	192	220	243	256	268	276	291	299	306	312	318	322	326	329	333	337	340
.90	.75	3	57	117	155	192	220	243	256	268	276	291	299	306	312	318	322	326	329	333	337	340
.80	.99	4	62	127	181	224	248	259	267	275	283	292	304	309	314	318	324	330	336	342	348	354
.80	.95	5	65	131	188	232	261	273	279	285	292	299	305	311	317	323	329	335	341	346	352	357
.80	.90	6	66	131	197	240	267	277	283	287	293	299	305	311	318	324	330	336	341	347	353	359
.80	.80	7	69	132	200	248	269	281	284	289	295	299	309	325	334	339	345	350	354	359	363	367
.80	.75	8	69	142	206	249	277	289	295	303	310	317	324	329	336	344	350	355	361	365	370	374
.75	.99	6	66	131	197	240	267	277	283	287	293	299	305	311	318	324	330	336	341	347	353	359
.75	.95	7	69	132	200	248	269	281	284	289	295	299	309	325	334	339	345	350	354	359	363	367
.75	.90	8	69	142	206	249	277	289	295	303	310	317	324	329	336	344	350	355	361	365	370	374
.75	.80	10	78	154	219	253	278	290	298	307	316	322	328	333	339	345	351	357	362	368	373	378
.75	.75	10	78	154	219	253	278	290	298	307	316	322	328	333	339	345	351	357	362	368	373	378
.50	.99	16	83	164	232	275	292	307	322	330	337	344	352	359	365	372	378	385	390	395	400	405
.50	.95	19	86	172	244	290	306	316	328	335	345	355	363	369	375	381	387	393	399	403	409	414
.50	.90	20	89	172	245	292	309	319	328	339	348	356	364	370	377	383	390	396	403	409	415	421
.50	.80	22	90	176	249	292	311	327	343	349	357	365	373	380	387	395	402	408	415	422	428	434
.50	.75	22	90	176	249	292	311	327	343	349	357	365	373	380	387	395	402	408	415	422	428	434
	MEAN (n=49)		93	184	260	306	326	338	349	358	368	377	386	394	402	410	418	425	432	438	445	451
	STANDARD DEVIATION		22	42	58	63	61	58	57	58	60	62	64	66	67	70	72	74	75	77	78	79
	COEFFICIENT OF VARIATION		24	23	22	21	19	17	16	16	16	16	17	17	17	17	17	17	17	18	18	18
	DRY/GREEN RATIO		1.97	2.00	2.00	2.06	2.14	2.16	2.15	2.14	2.13	2.11	2.10	2.09	2.07	2.06	2.05	2.04	2.03	2.03	2.02	2.01

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (White spruce)—continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m^2	Compression (In.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
95	80	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332
95	75	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332
90	95	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332
90	90	1	57	116	169	203	226	252	270	280	286	290	294	298	302	307	312	316	321	324	328	332
90	80	2	61	123	176	212	239	261	277	288	296	304	311	319	325	331	338	344	350	356	362	367
90	75	2	61	123	176	212	239	261	277	288	296	304	311	319	325	331	338	344	350	356	362	367
80	99	2	61	123	176	212	239	261	277	288	296	304	311	319	325	331	338	344	350	356	362	367
80	95	3	63	130	184	213	240	263	283	299	311	320	328	335	343	350	356	362	368	373	379	385
80	90	4	69	141	187	222	251	283	305	316	320	325	331	337	344	350	356	362	368	373	379	385
80	80	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397
80	75	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397
75	99	3	63	130	184	213	240	263	283	299	311	320	328	335	343	350	356	362	368	373	379	385
75	95	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397
75	90	5	71	142	195	225	257	286	307	322	330	337	343	350	356	362	369	375	381	386	392	397
75	80	6	71	142	199	229	259	291	315	323	331	337	344	351	358	364	370	377	383	390	397	403
75	75	7	72	143	201	231	268	297	316	326	333	342	350	357	363	369	376	382	388	394	400	405
50	99	10	76	154	212	252	293	320	346	364	378	386	393	401	408	414	421	428	435	442	449	455
50	95	12	76	158	224	270	304	334	359	372	384	393	402	411	420	428	435	442	448	455	461	468
50	90	13	82	164	227	279	321	350	364	374	388	397	406	414	421	428	436	444	451	457	463	469
50	80	15	85	171	244	293	331	359	376	386	393	402	412	420	428	436	444	451	459	466	473	480
50	75	15	85	171	244	293	331	359	376	386	393	402	412	420	428	436	444	451	459	466	473	480
	MEAN (n = 34)		91	183	258	310	347	372	389	402	412	422	433	442	451	460	469	477	486	493	501	509
	STANDARD DEVIATION		20	41	58	70	72	70	68	69	71	74	77	79	82	84	87	89	91	93	94	96
	COEFFICIENT OF VARIATION		22	22	22	23	21	19	17	17	17	18	18	18	18	18	19	19	19	19	19	19
	DRY/GREEN RATIO		2.19	2.19	2.21	2.25	2.24	2.17	2.12	2.08	2.07	2.05	2.04	2.04	2.03	2.03	2.03	2.02	2.02	2.01	2.00	2.00

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 20 compression levels (Northern red oak)--continued

Tolerance region Content (Pct. β)	Confidence (Pct. α)	m[2]	Compression (in.)																		
			.005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
.99	.80	1	53	117	162	213	262	303	320	340	360	381	400	421	440	460	478	495	511	527	545	557
.99	.75	1	53	117	162	213	262	303	320	340	360	381	400	421	440	460	478	495	511	527	545	557
.95	.99	3	73	179	222	290	359	394	419	438	456	468	481	494	506	519	531	541	550	558	566	574
.95	.95	5	89	189	256	339	383	420	434	446	462	497	526	550	577	597	609	621	633	646	661	674
.95	.90	6	92	197	290	341	397	423	478	514	529	544	558	572	584	604	621	633	643	653	664	675
.95	.80	7	94	204	301	375	415	458	494	516	533	550	566	582	597	611	622	634	645	656	666	676
.95	.75	7	94	204	301	375	415	458	494	516	533	550	566	582	597	611	622	634	645	656	666	676
.90	.99	10	107	225	336	400	466	529	546	565	588	631	662	674	685	698	709	719	729	737	746	754
.90	.95	12	115	233	343	440	502	551	591	623	638	650	671	701	714	727	739	750	760	769	778	786
.90	.90	13	118	242	345	441	509	564	596	626	646	667	685	701	722	738	750	760	771	783	797	812
.90	.80	15	119	244	349	459	544	568	611	636	666	688	706	723	737	753	766	785	798	810	821	828
.90	.75	16	122	244	349	460	544	596	612	639	667	697	713	729	745	762	773	790	806	818	827	835
.80	.99	25	135	262	374	479	571	633	677	713	730	745	767	789	809	825	837	847	859	872	888	906
.80	.95	28	138	275	402	508	573	653	702	728	753	779	792	807	824	846	865	879	894	913	933	946
.80	.90	30	140	279	407	521	581	659	705	733	762	780	797	818	836	856	873	902	915	925	937	964
.80	.80	32	140	287	409	524	591	674	707	742	774	796	814	840	858	878	899	915	930	945	960	974
.80	.75	33	141	287	409	530	595	675	707	746	779	808	829	845	865	884	899	919	938	954	971	992
.75	.99	33	141	287	409	530	595	675	707	746	779	808	829	845	865	884	899	919	938	954	971	992
.75	.95	37	144	293	422	542	622	686	717	766	809	839	859	876	895	911	923	940	956	970	990	1009
.75	.90	39	147	297	428	549	641	697	740	777	823	855	869	896	920	943	952	978	993	1008	1024	1040
.75	.80	41	148	304	443	556	646	699	755	786	832	861	897	926	942	955	975	992	1003	1015	1033	1060
.75	.75	42	149	306	443	562	652	699	766	791	833	872	899	932	952	973	989	1007	1027	1045	1064	1073
.50	.99	77	188	378	539	679	783	862	921	966	1000	1028	1052	1070	1094	1115	1131	1151	1155	1184	1205	1218
.50	.95	81	191	384	558	704	801	870	932	981	1009	1038	1062	1083	1102	1131	1151	1169	1184	1204	1223	1233
.50	.90	84	193	391	567	710	803	874	939	982	1021	1047	1075	1091	1116	1137	1156	1174	1190	1206	1229	1246
.50	.80	87	195	401	568	717	806	892	943	986	1027	1051	1077	1101	1121	1139	1165	1183	1198	1215	1236	1253
.50	.75	88	196	411	569	721	808	895	946	993	1029	1052	1079	1102	1121	1143	1167	1188	1202	1219	1244	1256
	MEAN (n=185)		216	424	584	723	819	897	946	987	1021	1052	1080	1106	1128	1153	1175	1195	1211	1229	1258	1277
	STANDARD DEVIATION		86	144	169	196	213	226	234	241	247	253	259	264	268	274	280	285	288	292	327	325
	COEFFICIENT OF VARIATION		40	34	29	27	26	25	25	24	24	24	24	24	24	24	24	24	24	24	26	25
	DRY/GREEN RATIO		2.42	1.95	1.76	1.66	1.62	1.60	1.59	1.58	1.57	1.57	1.56	1.56	1.56	1.56	1.55	1.54	1.56	1.56	1.50	1.51

Table 1. – Mean, standard deviation, coefficient of variation, tolerance limits,[1] and the dry/green ratio for each of 28 compression levels (Quaking aspen)—continued

Tolerance region Content (Pct. β)	Confidence (P. t. α)	m[2]	Compression (In.) .005	.010	.015	.020	.025	.030	.035	.040	.045	.050	.055	.060	.065	.070	.075	.080	.085	.090	.095	.100
95	75	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272
90	90	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272
90	80	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272
90	75	2	29	57	82	108	133	160	184	201	212	219	224	229	234	241	247	253	259	265	271	276
80	99	1	25	50	72	94	115	137	161	184	202	215	224	228	229	230	233	238	245	253	262	272
80	95	2	29	57	82	108	133	160	184	201	212	219	224	229	234	241	247	253	259	265	271	276
80	90	3	31	61	91	123	154	186	194	206	218	230	243	254	266	277	284	290	297	304	311	316
80	80	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316
80	75	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316
75	99	2	29	57	82	108	133	160	184	201	212	219	224	229	234	241	247	253	259	265	271	276
75	95	3	31	61	91	123	154	186	194	206	218	230	243	254	266	277	284	290	297	304	311	316
75	90	4	32	67	98	129	160	186	213	229	239	250	259	266	271	277	286	295	300	306	311	316
75	80	5	34	68	100	133	165	190	214	232	245	254	260	267	275	282	289	296	302	309	317	322
75	75	5	34	68	100	133	165	190	214	232	245	254	260	267	275	282	289	296	302	309	317	322
50	99	8	39	77	116	153	190	210	230	252	264	272	286	292	296	299	304	311	319	328	338	345
50	95	10	41	82	119	164	192	218	237	256	268	278	287	296	301	306	311	316	323	333	341	350
50	90	11	43	88	131	166	193	222	239	256	270	281	289	297	306	314	321	327	332	336	346	351
50	80	12	45	89	132	169	194	223	242	260	273	282	291	302	314	320	324	329	336	343	348	353
50	75	12	45	89	132	169	194	223	242	260	273	282	291	302	314	320	324	329	336	343	348	353
		MEAN (n = 28)	48	94	138	180	209	234	254	272	286	299	308	316	322	328	334	340	346	353	360	367
		STANDARD DEVIATION	12	23	34	41	41	41	40	41	43	45	48	51	52	53	54	53	53	53	53	53
		COEFFICIENT OF VARIATION	25	24	25	23	20	18	16	15	15	15	16	16	16	16	16	16	15	15	15	14
		DRY/GREEN RATIO	2.62	2.69	2.64	2.75	2.91	2.83	2.79	2.73	2.68	2.66	2.66	2.66	2.64	2.62	2.58	2.56	2.53	2.51	2.50	2.49

[1]Mean, standard deviation, and tolerance limits are in lb/in.^{2}; coefficient of variation is percent.

[2]We are α percent confident that β percent of the population sampled $\geq$ the mth smallest observation.

[3]In an effort to reduce the large amount of computation required for table 1, no Interior North Douglas-fir air dry specimens were included in the analysis. It is assumed that the dry/green ratios for Coast Douglas-fir apply to Douglas-fir from all geographic regions.

Table 2.—Statistics for the regression model log y = A + B log x where y is either the mean or a tolerance limit stress (lb/in²) and x is an average D 2555 modulus of elasticity value for a species

Regression No.	Tolerance limit		Compression	Regression coefficients		r^2	n	Residual mean square	$\overline{\log x}$	$\log \sum x^2$
	Tolerance region	Confidence		A	B					
	Pct	Pct	In.							
				TOLERANCE LIMIT VERSUS MODULUS OF ELASTICITY						
1	95	75	0.02	-0.5975 + 01	0.1352 + 01	0.402	9	0.2086 - 01	0.6099 + 01	0.3348 + 03
2	95	75	.04	-.4775 + 01	.1189 + 01	.504	9	.1069 - 01	.6099 + 01	.3348 + 03
3	95	75	.06	-.4616 + 01	.1173 + 01	.507	9	.1028 - 01	.6099 + 01	.3348 + 03
4	95	75	.08	-.5003 + 01	.1241 + 01	.550	9	.9671 - 02	.6099 + 01	.3348 + 03
5	95	75	.10	-.4472 + 01	.1159 + 01	.506	9	.1005 - 01	.6099 + 01	.3348 + 03
6	95	95	.02	.2811 + 01	-.8444 - 01	.000	6	.3574 - 01	.6147 + 01	.2267 + 03
7	95	95	.04	.9094 + 00	.2592 + 00	.003	6	.2219 - 01	.6147 + 01	.2267 + 03
8	95	95	.06	.1201 + 01	.2247 + 00	.002	6	.1820 - 01	.6147 + 01	.2267 + 03
9	95	95	.08	.1372 + 01	.2030 + 00	.002	6	.1831 - 01	.6147 + 01	.2267 + 03
10	95	95	.10	.1607 + 01	.1693 + 00	.001	6	.1853 - 01	.6147 + 01	.2267 + 03
11	75	75	.02	-.6792 + 01	.1513 + 01	.467	9	.2003 - 01	.6099 + 01	.3348 + 03
12	75	75	.04	-.6024 + 01	.1414 + 01	.502	9	.1520 - 01	.6099 + 01	.3348 + 03
13	75	75	.06	-.5985 + 01	.1416 + 01	.487	9	.1620 - 01	.6099 + 01	.3348 + 03
14	75	75	.08	-.5650 + 01	.1366 + 01	.466	9	.1639 - 01	.6099 + 01	.3348 + 03
15	75	75	.10	-.5411 + 01	.1332 + 01	.454	9	.1636 - 01	.6099 + 01	.3348 + 03
16	75	95	.02	-.7172 + 01	.1573 + 01	.481	9	.2050 - 01	.6099 + 01	.3348 + 03
17	75	95	.04	-.6928 + 01	.1560 + 01	.555	9	.1498 - 01	.6099 + 01	.3348 + 03
18	75	95	.06	-.6169 + 01	.1444 + 01	.518	9	.1489 - 01	.6099 + 01	.3348 + 03
19	75	95	.08	-.5588 + 01	.1354 + 01	.488	9	.1476 - 01	.6099 + 01	.3348 + 03
20	75	95	.10	-.5346 + 01	.1319 + 01	.466	9	.1527 - 01	.6099 + 01	.3348 + 03
21	50	75	0.02	-0.7613 + 01	0.1655 + 01	0.527	9	0.1906 - 01	0.6099 + 01	0.3348 + 03
22	50	75	.04	-.7182 + 01	.1617 + 01	.546	9	.1671 - 01	.6099 + 01	.3348 + 03
23	50	75	.06	-.6783 + 01	.1559 + 01	.536	9	.1614 - 01	.6099 + 01	.3348 + 03
24	50	75	.08	-.6556 + 01	.1527 + 01	.525	9	.1621 - 01	.6099 + 01	.3348 + 03
25	50	75	.10	-.6374 + 01	.1501 + 01	.519	9	.1605 - 01	.6099 + 01	.3348 + 03
26	50	95	.02	-.7614 + 01	.1663 + 01	.504	9	.2091 - 01	.6099 + 01	.3348 + 03
27	50	95	.04	-.7235 + 01	.1624 + 01	.537	9	.1741 - 01	.6099 + 01	.3348 + 03
28	50	95	.06	-.6828 + 01	.1565 + 01	.529	9	.1674 - 01	.6099 + 01	.3348 + 03
29	50	95	.08	-.6849 + 01	.1573 + 01	.536	9	.1647 - 01	.6099 + 01	.3348 + 03
30	50	95	.10	-.6456 + 01	.1513 + 01	.518	9	.1631 - 01	.6099 + 01	.3348 + 03
				MEAN VERSUS MODULUS OF ELASTICITY						
31	MEAN		.02	-.7477 + 01	.1647 + 01	.569	9	.1574 - 01	.6099 + 01	.3348 + 03
32	...do...		.04	-.7195 + 01	.1622 + 01	.598	9	.1355 - 01	.6099 + 01	.3348 + 03
33	...do...		.06	-.6805 + 01	.1566 + 01	.581	9	.1359 - 01	.6099 + 01	.3348 + 03
34	...do...		.08	-.6682 + 01	.1551 + 01	.576	9	.1360 - 01	.6099 + 01	.3348 + 03
35	...do...		.10	-.6428 + 01	.1514 + 01	.561	9	.1377 - 01	.6099 + 01	.3348 + 03

Table 3.—Statistics for the regression model $y = A + Bx$ where y is either the mean or a tolerance limit stress (lb/in.^{2}) and x is an average D 2555 specific gravity value for a species

Regression No.	Tolerance limit: Tolerance region	Tolerance limit: Confidence	Compression level	Regression coefficients: A	Regression coefficients: B	r^2	n	Residual mean square	$\bar{x}$	Σx^2
	Pct	Pct	In.							
				TOLERANCE LIMIT VERSUS SPECIFIC GRAVITY						
1	95	75	0.02	-0.1551 + 03	0.8721 + 03	0.652	9	0.2751 + 04	0.4069 + 00	0.1537 + 01
2	95	75	.04	-.1569 + 03	.1158 + 04	.752	9	.2994 + 04	.4069 + 00	.1537 + 01
3	95	75	.06	-.1857 + 03	.1341 + 04	.785	9	.3337 + 04	.4069 + 00	.1537 + 01
4	95	75	.08	-.2138 + 03	.1476 + 04	.803	9	.3625 + 04	.4069 + 00	.1537 + 01
5	95	75	.10	-.2211 + 03	.1560 + 04	.805	9	.3987 + 04	.4069 + 00	.1537 + 01
6	95	95	.02	-.2345 + 03	.1001 + 04	.746	6	.2060 + 04	.4425 + 00	.1199 + 01
7	95	95	.04	-.1346 + 03	.1050 + 04	.615	6	.4152 + 04	.4425 + 00	.1199 + 01
8	95	95	.06	-.1696 + 03	.1274 + 04	.700	6	.4186 + 04	.4425 + 00	.1199 + 01
9	95	95	.08	-.2146 + 03	.1457 + 04	.708	6	.5274 + 04	.4425 + 00	.1199 + 01
10	95	95	.10	-.2553 + 03	.1615 + 04	.732	6	.5737 + 04	.4425 + 00	.1199 + 01
11	75	75	.02	-.2855 + 03	.1427 + 04	.743	9	.4764 + 04	.4069 + 00	.1537 + 01
12	75	75	.04	-.4072 + 03	.2048 + 04	.830	9	.5802 + 04	.4069 + 00	.1537 + 01
13	75	75	.06	-.5174 + 03	.2453 + 04	.854	9	.6997 + 04	.4069 + 00	.1537 + 01
14	75	75	.08	-.5573 + 03	.2639 + 04	.859	9	.7756 + 04	.4069 + 00	.1537 + 01
15	75	75	.10	-.5859 + 03	.2789 + 04	.854	9	.8980 + 04	.4069 + 00	.1537 + 01
16	75	95	.02	-.2741 + 03	.1375 + 04	.727	9	.4804 + 04	.4069 + 00	.1537 + 01
17	75	95	.04	-.4083 + 03	.2017 + 04	.825	9	.5842 + 04	.4069 + 00	.1537 + 01
18	75	95	.06	-.4688 + 03	.2297 + 04	.856	9	.6010 + 04	.4069 + 00	.1537 + 01
19	75	95	.08	-.4888 + 03	.2434 + 04	.862	9	.6402 + 04	.4069 + 00	.1537 + 01
20	75	95	.10	-.5280 + 03	.2605 + 04	.860	9	.7501 + 04	.4069 + 00	.1537 + 01
21	50	75	0.02	-.4130 + 03	0.1947 + 04	0.786	9	0.6990 + 04	0.4069 + 00	0.1537 + 01
22	50	75	.04	-.5974 + 03	.2743 + 04	.861	9	.8222 + 04	.4069 + 00	.1537 + 01
23	50	75	.06	-.6560 + 03	.3016 + 04	.871	9	.9114 + 04	.4069 + 00	.1537 + 01
24	50	75	.08	-.7044 + 03	.3236 + 04	.875	9	.1017 + 05	.4069 + 00	.1537 + 01
25	50	75	.10	-.7315 + 03	.3393 + 04	.870	9	.1162 + 05	.4069 + 00	.1537 + 01
26	50	95	.02	-.4181 + 03	.1932 + 04	.784	9	.6961 + 04	.4069 + 00	.1537 + 01
27	50	95	.04	-.6051 + 03	.2729 + 04	.859	9	.8258 + 04	.4069 + 00	.1537 + 01
28	50	95	.06	-.6535 + 03	.2981 + 04	.870	9	.8988 + 04	.4069 + 00	.1537 + 01
29	50	95	.08	-.7076 + 03	.3214 + 04	.873	9	.1020 + 05	.4069 + 00	.1537 + 01
30	50	95	.10	-.7322 + 03	.3361 + 04	.874	9	.1103 + 05	.4069 + 00	.1537 + 01
				MEAN VERSUS SPECIFIC GRAVITY						
31	MEAN		.02	-.3770 + 03	.1902 + 04	.786	9	.6677 + 04	.4069 + 00	.1537 + 01
32	do		.04	-.5513 + 03	.2674 + 04	.870	9	.7238 + 04	.4069 + 00	.1537 + 01
33	do		.06	-.6197 + 03	.2990 + 04	.888	9	.7645 + 04	.4069 + 00	.1537 + 01
34	do		.08	-.6659 + 03	.3211 + 04	.887	9	.8925 + 04	.4069 + 00	.1537 + 01
35	do		.10	-.7057 + 03	.3403 + 04	.885	9	.1016 + 05	.4069 + 00	.1537 + 01

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